Chapter 15
Impacts of Electric Mobility on the Electric Grid

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ABSTRACT

Electric mobility is becoming an option for reducing greenhouse gas emissions of road transport and decreasing the external dependence on fossil fuels. However, this new kind of mobility will introduce additional loads to the power system, and it is important to determine its effects on it. As a direct scenario from DATA SIM FP7 EU project, an application related to electric mobility and its impact on the electric grid from Flanders region is presented in this chapter. The chapter begins with a brief description of the electric transmission network for Flanders region and the electric vehicles energy requirements for different mobility zones in this region, obtained from FEATHERS, an activity-based model. In the following section, the main assumptions that allow estimating the total electricity consumption for each mobility area is presented. Once this total consumption per zone has been estimated, an algorithm to link the mobility areas with the nearest substation is developed. Finally, the impact of charging electric vehicles on the transmission substations is examined.

INTRODUCTION

Some of the major concerns of the European Commission are climate change and energy. In 2009 the EU adopted a complete package (the well-known ‘20-20-20’ targets to be achieved in 2020) focuses in three different but related areas: promoting both renewable energies and energy efficiency, and reducing emissions. These targets are the following (http://ec.europa.eu/clima/policies/package/documentation_en.htm):

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• Europe has to reduce greenhouse gas (GHG) emissions at least 20% below 1990 levels.
• 20% of EU energy consumption has to come from renewable resources.
• 20% reduction in primary energy use compared with projected levels has to be achieved by improving energy efficiency.

Following the initial EU lines in this theme, the European Commission presented in 2011 the “Energy Roadmap 2050” (http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf). This document presents main solutions to achieve a goal of cutting emissions by over 80% by 2050, without disrupting energy supplies and competitiveness of the European countries.

In order to reach these objectives, it is necessary to reduce the overall emissions, mainly in transport (reducing CO2, NOx and other pollutants), so road transportation must be decarbonized through a high deployment of battery electric and plug-in hybrid electric vehicles (BEVs – or simply EVs- and PHEVs).

These types of vehicles will be part of the global solution for climate change but also they could be a huge problem, because the total electricity demand will grow up in the future and the charging of EVs and PHEVs will have an important impact on the electric grid, especially under uncoordinated charging conditions.

Investments in electricity networks are very expensive and costly in time; therefore it is important to anticipate the impact of a massive deployment of electric vehicles in the electric grid. At the same time, electric companies plan their electricity networks taking into account that consumptions, in different nodes of the electric grid, vary continuously in time but these loads are assumed to be static in space.

With the introduction of electric vehicles and their inherent electric mobility, there will also be a remarkable spatial variation in the electric loads that could increase the total stress on the power grid. This stress can also cause changes in the behavior of electric vehicle drivers, since they will not be able to recharge at the desired locations and at the desired times due to charging restrictions.

The main objective of the FP7 EU DataSim Project (http://www.uhasselt.be/datasim) is to provide an entirely new and highly detailed spatial-temporal micro-simulation methodology for human mobility. This methodology is based on massive amounts of big data from different sources. One of the outputs of this project is an activity-based micro-simulation model (ActBM) for traffic forecasting called Feathers, which has been used to predict spatial and temporal electrical vehicle power demand in the region of Flanders (Knapen, Luk; Kochan, Bruno; Bellemans, Tom; Janssens, Davy & Wets, Geert; 2011).

The main objective of this chapter is to study the impact of the electric vehicles’ load integration on the electric grid according to a rate of market penetration and different charging scenarios by using accurate information about the spatial and temporal electric load demand due to the electric mobility.

This analysis will be useful to foresee whether the growing presence of electric vehicles could provoke technical problems in the transmission grid. In a second stage, this analysis will allow to evaluate the capacity of the electric vehicles to promote the integration of renewable energies and the availability of this type of vehicles to offer new services such as vehicle to grid applications (V2G), creating new business models. Note that, in some electricity markets, due to their specific rules, the ancillary services (frequency regulation, voltage control, etc.) have to be provided from specific nodes of the transmission grid (Bessa, Ricardo J. and Matos, Manuel A., (2010)). Hence the importance of carrying out this analysis based on a zonal approach.

In this chapter the particular case of the Flemish electric grid is studied, starting from the Activity Based models (AB models) basis, developed in Knapen, Luk; Kochan, Bruno; Bellemans, Tom;